Title

The association between tobacco control policies and current smoking across different occupational groups in the EU between 2009 and 2017

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Keyword

Tobacco, Public Health, Statistics, Multilevel Modelling, Tobacco Control

Word Count (excluding title page, abstract, references, figures and tables)

3,597

Reference Count

37

Abstract

Background

This study investigated the cross-national and longitudinal associations between national tobacco control policies and current smoking in 28 European Union (EU) member states between 2009 and 2017. It also examined the interaction between tobacco control policies and occupational status.

Methods

We used data from four waves of Eurobarometer (2009, 2012, 2014 and 2017). The total sample size was 105,231 individuals aged ≥15 years. Tobacco Control Scale scores (range 0 to 100) for years 2005, 2007, 2012 and 2014 measured the strength of country-level tobacco control policies. Logistic multilevel regression analyses with three levels (the individual, the country-year and the country) were performed with current smoker as the dependent variable.

Results

Across the EU, average smoking prevalence fell from 29.4% (95% CI: 28.5% to 30.2%) in 2009 to 26.3% (95% CI: 25.4% to 27.1%) in 2017. We confirmed that cross-nationally, strong national tobacco control policies are significantly associated with low probability of smoking. A one-point increase in TCS score was associated with lower odds of smoking (OR = 0.990; 95% CI = 0.983 to 0.998), but longitudinally (within-country) increases in TCS were not associated with current smoking (OR = 0.999; 95% CI = 0.994 to 1.005). Compared to those in manual occupations, the cross-national association was stronger in the upper occupational group (Conditional OR for the interaction = 0.985; 95% CI = 0.978 to 0.992) and weaker in the economically inactive group (Conditional OR for the interaction 1.009; 95% CI: 1.005 to 1.013).

Conclusion

Differences in tobacco control policies between countries were associated with probability of smoking but the changes in TCS within countries over time were not. Differences between countries in tobacco control policies were found to be most strongly associated with likelihood of smoking in the highest occupational groups and were found to have only a weak association with smoking among the economically inactive in this sample.

Word Count: 309

What is already known on this subject?

- Smoking prevalence is higher among people with low socioeconomic status, but the effect of strength of tobacco control policies on subject specific odds of smoking in people of different occupational groups was unknown.
- No previous studies have investigated the cross-national (between-country) and longitudinal (within-country) associations between tobacco control policies and probability of smoking.

What does this paper add?

- Strong tobacco control policies are significantly associated with lower odds of being a current smoker.
- The association between national tobacco control policies and current smoking varies significantly across occupational groups. There is a stronger association in upper class occupations compared to those in manual occupations. The association between strength of tobacco control policies also appears significantly weaker among the economically inactive compared to those in manual occupations.

INTRODUCTION

In Europe, tobacco remains the single largest cause of preventable mortality and is responsible for almost 700,000 premature deaths per year.[1] Despite national efforts to reduce smoking prevalence, adult smoking prevalence in many European Union (EU) member states remains high. The most recent Eurobarometer special report on attitudes of Europeans towards tobacco and e-cigarettes found that 26% of the EU citizens were current smokers in 2017.[2] This represents only a three percentage point decline on smoking prevalence rates in EU citizens over an eight year period.[3] There are not only marked differences in trends in smoking prevalence between member states, smoking and smoking related harms are also subject to substantial social inequalities.[4] There is also considerable variation in the strength of nationwide tobacco control policies in the EU even though tobacco products have been heavily regulated over past decades.[5-8] It is known that this variation is strongly associated with county-level smoking prevalence.[9-12] However, less is known about the association between tobacco regulatory environment and socioeconomic status.

Socioeconomic status or position is a complex concept and 'refers to the social and economic factors that influence what positions individuals or groups hold within the structure of a society'.[13] Occupation reflects how an individual's early life experiences including education, biological inheritance, parental background, experience of habitus and distinction and discrimination during development crystallise as a location within society's power structures in adulthood.[14] Occupational status is widely used as an index of socioeconomic position in European studies and has been found to predict mortality risk more accurately than measures of education.[15]

The impact of tobacco control policies on inequalities has become a focus in recent years but the evaluation of differential effects of policy is hampered by a lack of evidence.[16] There have been only two cross-national studies in the last decade examining the effect of strength of tobacco control policies on quit ratios and tobacco consumption across socioeconomic groups, as measured by education and or occupational status.[11 17] Bosdriesz, et al. [17] found that the there was a weaker association between country-level tobacco control policies and smoking cessation, as well as tobacco consumption amongst the economically inactive compared to those in manual occupations. Meanwhile, Schaap, et al. [11] showed that the association between quit ratios and national tobacco regulatory environment did not

differ between high and low educational groups. This could be due to the time difference between when the studies were conducted or to methodological differences. There has been no research at all in the last decade that examines occupational socioeconomic gradients in the impact of national tobacco control policies on smoking prevalence in adults. Examining change in smoking prevalence over time is important as this reflects both the number of smokers in a population quitting plus changes in the proportion of people taking up smoking.[18]

The present study has three aims. Firstly, to describe changes in smoking prevalence over time within the EU member states between 2009 and 2017. Secondly, to describe how within- and between-country variations in the implementation of tobacco control policies are associated with the current smoking in individuals. And finally, to describe how these variations affect individuals of different socioeconomic positions, as measured by occupational status.

METHODS

Data Sources

This study used secondary data obtained from four waves of Eurobarometer survey: wave 72.3 (October 2009), wave 77.1 (February – March 2012), wave 82.4 (November – December 2014) and wave 87.1 (March 2017). The Eurobarometer is funded by the European Commission and has a repeated cross-sectional and cross-national design. It employs a multi-stage sampling design to collect nationally representative data for population aged ≥ 15 in each country or region. Post-stratification weights and population size weights are available in the data.[2 3 19-21]

The initial study population was based on four waves of Eurobarometer and consisted of 112,745 respondents from 31 European countries. For analysis purposes, we only included data from the current 28 EU member states. All member states participated in all four waves of Eurobarometer, except for Croatia which participated in only three waves (waves 72.3, 82.4 and 87.1). After list-wise deletion of respondents with missing values on dependent and independent variables, the final analysis sample size was 105,231 (see supplementary file table S1 for the number of respondents per country and per survey).

Measures

Current Tobacco Use

All participants were asked about their current smoking status. In the 2009 and 2012 surveys, they were asked "Regarding smoking cigarettes, cigars or a pipe, which of the following applies to you?" while the participants in the 2014 and 2017 surveys were asked "Regarding smoking cigarettes, cigars, cigarillos or a pipe, which of the following applies to you? In this question and the following questions in this section, smoking cigarettes does not include use the electronic cigarettes." Although there were some small differences in the question wording across the four waves of survey, response options were consistent: "You currently smoke", "You used to smoke but you have stopped" and "You have never smoked". Individuals who answered "You currently smoke" were classified as *current* smokers, those answered "You used to smoke but you have stopped" and "You have never smoked" were classified as *former/ never* smokers.

Sociodemographic Characteristics

The data contained information on the gender (male and female), participants' age band (15-24; 25-34; 35-44; 45-54; 55-64 and ≥65 years old), marital status (never married; married or single with partner; divorced or separated; widowed and other), education level (measured as the age when they stopped full-time education: no full time education or ≤15; 16-19; ≥20 years and still in full-time education) and area of residence (rural area; small or middle town and large town). Occupation was used as a proxy for social class with the following categorisation: manual class (e.g., farmers and manual workers); middle class (e.g., craftsmen, business proprietors and desk workers); upper class (e.g., professionals) and economically inactive (e.g., students, unemployed and retired). Difficulties in paying bills during the last twelve months (most of the time; from time to time and almost never/ never) was used as a proxy for income. The correlations between these variables did not exceed 0.4 and the variance inflation factors were below 2.0, indicating the absence of multicollinearity. The characteristics of the final analysis sample are presented in Supplementary Table 2. Since half of the survey population belongs to the economically inactive group and are likely to be heterogeneous, we also present a table characterising the economically inactive group in terms of gender, age band, marital status and education level (Supplementary Table 3).

Tobacco Control Scale (TCS)

The Tobacco Control Scale (TCS), designed by Joossens and Raw [5] (2006) to quantify and measure the implementation of tobacco control policies at country-level, has been widely used to monitor national policy development and implementation.[5 9 11 12] The TCS quantifies the implementation of national-level tobacco control polices using a scale ranging from zero to 100, with higher scores indicating more comprehensive policies and implementation. Based on the recommendations from the World Bank, it contains measures on six policies: tobacco taxes; smoke-free laws; public information campaigns; advertising bans; health warning labels; and cessation supports.[5] The maximum number of points for each policy was determined based on both scientific evidence and expert opinion, while the actual allocation of points was based on policy implementation information provided by national tobacco control experts from each country.[5] The TCS scoring system has been revised over time. Bosdriesz, et al. [17] (2016) recalculated the TCS scores for 2005, 2007 and 2010 based on the 2013 scoring system to make the score more comparable. In our analysis, we adopted these recalibrated TCS scores. We anticipated a lag effect of tobacco control policies on smoking prevalence of four to five years, therefore, the TCS scores of 2005, 2007, 2010 and 2013 were assigned to the 2009, 2012, 2014 and 2017 Eurobarometer data respectively. This was based on two very recent studies that found a relationship between TCS[9] and MPOWER[22] scores and changes in smoking prevalence in the EU. In these studies, a period of seven years was chosen to be certain that it was in the range over which policies have been shown to be correlated with prevalence. As the TCS was initially released in 2005, it was not possible for us to use a seven-year lag in our study. Therefore, the maximum period of lag effect could only be four to five years.

Statistical Analysis

The Eurobarometer data has a three-level hierarchical structure: individuals (level 1) are nested within country-years (level 2), which are then clustered within countries (level 3). Therefore, a multilevel modelling approach was adopted to account for statistical dependency among observations. We used a three-level random slope logistic model to examine the association between strength of national tobacco control policies and the trend in current smoking among 28 EU countries between 2009 and 2017. Figure 1 presents the structure of our proposed multilevel model. The analysis was performed by

contrasting *current* smokers with other smoking statuses (*former* and *never* smokers), and was adjusted for sociodemographic characteristics.

We followed the approach of Fairbrother [23] to disentangle the cross-country association from the longitudinal association between tobacco control policies and probability of smoking. This was done by decomposing the overall effect into two separate components: cross-sectional (between-country) and longitudinal (within-country). We averaged the TCS scores of 2005, 2007, 2010 and 2013 for each country to capture the cross-sectional (or cross-national) relationship between the strength of tobacco control policies and the odds of being a current smoker (also known as the *between-country effect*). We, then, subtracted country means from the country-year specific TCS score to capture the longitudinal effect on the odds of being a current smoker over time within each country (also known as the *within-country effect*). By group-mean centring the TCS score, the cross-sectional effects for tobacco control policies are orthogonal to the longitudinal effects. Therefore, we were able to obtain two separate coefficients to represent the between- and within-country effects.[23]

Our analysis was comprised of a series of multilevel models. We started with a three-level null model with only random intercepts at the individual-, country-year- and country-level (Model 1). To explore the trend in current smoking between 2009 and 2017, a three-level random intercept logistic regression model was fitted with year (recoded as 0, 3, 5, and 8 for 2009, 2012, 2014 and 2017 respectively) as a continuous predictor (Model 2). In Model 3, year was further included as the random slope at the country-level to determine whether the longitudinal trends in current smoking varied across countries. To investigate whether there is any association between strength of tobacco control policies and smoking, Model 4 included the country cross-sectional and longitudinal components of the TCS. Finally, a cross-level interaction between occupation (individual-level) and the cross-sectional component of TCS (country-level) was included to the final model to examine whether the association between the strength of tobacco control policies and smoking varies across occupational groups (Model 5). Except for the null model, all models were adjusted for gender, age, occupation, marital status, education level, area of residence and difficulty in paying bills. Figure 1 specifies the different variables that were included in the models.

The Markov Chain Monte Carlo (MCMC) method was used to estimate all models because this Bayesian estimation approach produces less biased estimates than the commonly used maximum likelihood method especially when there are around 30 countries in the data.[24] We used the Deviance Information Criterion (DIC), a generalisation of Akaike Information Criterion (AIC), for model selection.[25 26] The DIC is a Bayesian analogue of AIC and a small DIC indicates a better model fit.[25] All analysis were performed by MLwiN version 3.02[27 28] through R using the package R2MLwiN [29]. Post-stratification weights provided in the Eurobarometer datasets were used in the analyses.

RESULTS

Current Smoking Prevalence

The prevalence of current smoking across the 28 EU member states (EU28) decreased from 29.4% (95% CI: 28.5% to 30.2%) in 2009 to 26.3% (95% CI: 25.4% to 27.1%) in 2017. Figure 2a shows the change in smoking prevalence in the EU28, with the majority showing a decrease between 2009 and 2017. However, seven member states (Croatia, Czech Republic, France, Germany, Portugal, Slovakia and Slovenia) showed an increase in smoking prevalence, but the differences were not significant at the 5% level. Therefore, we cannot rule out that these increases were due to random sampling variation.

Tobacco Control Scale

Although there was a general increasing trend in TCS score across the EU28 between 2005 and 2013 (Figure 2b), the change was small, showing that EU tobacco control policies have not changed radically over the past decade. The UK and Ireland consistently scored the highest, while Luxembourg, Germany and Austria consistently scored the lowest.

Results of Multilevel Models

Table 1 presents the null model (Model 1), an empty model without any fixed effects. Results indicate that there was significant variation in both country- and country-year levels. Despite the fact that these variances are small, they are statistically significant at the 1% level. Hence, we accounted for these unobserved heterogeneities by using a three-level logistic model.

Next, we included the linear effect of time as a predictor into the null model, adjusting for individual-level sociodemographic variables. The results show that between 2009 and 2017, the odds of being a current smoker decreased (Table 1, Model 2). Thus, on average, there was a significant decrease in

probability of current smoking in the EU28 in this time period. To examine whether the trends in smoking varied across countries, a random slope for the time effect was included at the country-level (Table 1, Model 3). The random slope was significant, indicating that although the general trend was a decreasing probability of smoking, smoking only decreased in some countries, with the remaining countries showing either an increase or a stable probability of smoking.

We, then, investigated the association between of tobacco control policies and current smoking by introducing TCS scores into Model 4 (Table 2). As noted above, we decomposed the TCS score into cross-sectional and longitudinal components to estimate between- and within-country effects of tobacco control policies on current smoking. The estimated odds ratios for the average TCS score was 0.990 (95% CI: 0.983 to 0.998), indicating that the cross-sectional component of TCS significantly influenced the odds of an individual being a current smoker. Therefore, national tobacco control policies had a significant between-country effect on probability of smoking. In countries with stricter tobacco control regulations, probabilities of smoking tended to be lower. However, the longitudinal component of TCS score (OR = 0.999; 95% CI: 0.994 to 1.005) indicates that the within-country effect of tobacco control policies was not statistically significant. Thus, even though national tobacco control regulations changed over time, the *rate of change* had no effect on probability of smoking.

Finally, a cross-level interaction between individual social class measures and country's average TCS score is included in Model 5 (Table 2). The results indicate that the association between cross-sectional effects of tobacco control policies and current smoking differed across occupational groups. Compared to those in manual occupations, the association between strength of tobacco control policies is weaker among the economically inactive (OR = 1.009; 95% CI: 1.005 to 1.013) and stronger in upper class occupations (OR = 0.985; 95% CI: 0.978 to 0.992). Figure 3 shows a predicted probability plot. The plot suggests that the impact of tobacco control regulations is stronger on those who work in upper class occupations, whereas the impact on those who are economically inactive is apparently weaker.

Sensitivity Analyses

There are three available measures that could be used as an indicator of socioeconomic position. The indicators occupation, education level and difficulties paying bills capture different elements of socioeconomic advantage. Our study used occupation as a proxy for social class. We have examined

the model fit of models using alternative available measures of socioeconomic group. The current model with an interaction between TCS and occupation has a better fit (by DIC criteria) than the models with an interaction between TCS and education level (Model 6 in Supplementary Table 4) or, between TCS and difficulty paying bills (Model 7 in Supplementary Table 4). We have also performed another sensitivity analysis using a shorter time lag for TCS. In the sensitivity analysis, we assigned 2007, 2012, 2014 and 2016 for 2009, 2012, 2014 and 2017 Eurobarometer data. The result is presented in Supplementary Table 5 (Model 8).

Table 1 Random Effects for the 3-level Multilevel Models

	Model 1		**Model 2**		**Model 3**	
	OR	95% CI	OR	95% CI	OR	95% CI
Intercept	0.351***	(0.312, 0.396)	2.031***	(1.787, 2.308)	2.028***	(1.773, 2.316)
Year			0.985**	(0.977, 0.994)	0.986*	(0.973, 0.999)
Fixed effects						
Individual-level						
Gender *(Ref. Man)*						
Woman			0.569***	(0.552, 0.586)	0.569***	(0.552, 0.586)
Age *(Ref. 15-24 years old)*						
25-34 years old			0.978	(0.912, 1.048)	0.979	(0.913, 1.049)
35-44 years old			0.850***	(0.791, 0.913)	0.850***	(0.791, 0.913)
45-54 years old			0.790***	(0.735, 0.849)	0.791***	(0.736, 0.849)
55-64 years old			0.549***	(0.510, 0.591)	0.550***	(0.511, 0.591)
65 years old and older			0.216***	(0.199, 0.234)	0.217***	(0.200, 0.235)
Social class *(Ref. manual class)*						
Middle class			0.754***	(0.720, 0.790)	0.753***	(0.719, 0.788)
Upper class			0.600***	(0.553, 0.652)	0.600***	(0.553, 0.651)
Inactive			0.932**	(0.889, 0.976)	0.930**	(0.887, 0.975)
Marital status *(Ref. never married)*						
Married/ single with partner			0.747***	(0.716, 0.779)	0.747***	(0.716, 0.779)
Divorced/ separated			1.414***	(1.329, 1.505)	1.413***	(1.328, 1.503)
Widowed			0.730***	(0.677, 0.788)	0.730***	(0.677, 0.788)
Other			0.884	(0.767, 1.018)	0.888	(0.771, 1.022)
Year of education *(Ref. no full-time education/ less than 15 years)*						
16-19 years			1.064**	(1.016, 1.114)	1.064**	(1.016, 1.113)

	Model 1		Model 2		Model 3	
	OR	95% CI	OR	95% CI	OR	95% CI
20 years and more			0.689***	(0.653, 0.726)	0.689***	(0.653, 0.726)
Still studying			0.326***	(0.297, 0.358)	0.326***	(0.297, 0.357)
Community type *(Ref. rural area/ village)*						
Small/ middle town			1.120***	(1.081, 1.160)	1.119***	(1.079, 1.159)
Large town			1.220***	(1.174, 1.267)	1.220***	(1.174, 1.267)
Difficulty in paying bills *(Ref. most of the time)*						
From time to time			0.713***	(0.679, 0.748)	0.713***	(0.680, 0.749)
Almost never/ never			0.487***	(0.464, 0.511)	0.488***	(0.465, 0.513)
	Variance	95% CI	Variance	95% CI	Variance	95% CI
Random effects						
Country-level intercept	0.095***	(0.052, 0.169)	0.048***	(0.025, 0.086)	0.063***	(0.034, 0.112)
Country-level slope on year					0.001*	(0.000, 0.002)
Country-year-level intercept	0.023***	(0.016, 0.034)	0.013***	(0.008, 0.020)	0.004**	(0.001, 0.009)
DIC	119,747		110,105		110,095	

* p<0.05, **p<0.01, ***p<0.001

Table 2 Three-level Random Slope Logistic Regression Model with Smoking Status as Dependent Variable

	Model 4		**Model 5**	
	OR	95% CI	OR	95% CI
Intercept	3.053***	(2.167, 4.412)	3.317***	(2.310, 4.926)
Year	0.986*	(0.973, 0.999)	0.986*	(0.973, 1.000)
Fixed effects				
Individual-level				
Gender *(Ref. Man)*				
Woman	0.569***	(0.552, 0.586)	0.568***	(0.551, 0.585)
Age *(Ref. 15-24 years old)*				
25-34 years old	0.978	(0.913, 1.048)	0.979	(0.913, 1.049)
35-44 years old	0.850***	(0.791, 0.912)	0.848***	(0.790, 0.910)
45-54 years old	0.790***	(0.736, 0.848)	0.790***	(0.735, 0.848)
55-64 years old	0.550***	(0.511, 0.591)	0.551***	(0.512, 0.593)
65 years old and older	0.217***	(0.200, 0.235)	0.216***	(0.200, 0.235)
Social class *(Ref. manual class)*				
Middle class	0.753***	(0.719, 0.789)	0.896	(0.742, 1.078)
Upper class	0.601***	(0.554, 0.651)	1.153	(0.838, 1.590)
Inactive	0.930**	(0.887, 0.976)	0.626***	(0.526, 0.747)
Marital status *(Ref. never married)*				
Married/ single with partner	0.747***	(0.716, 0.779)	0.750***	(0.718, 0.782)
Divorced/ separated	1.412***	(1.328, 1.503)	1.412***	(1.327, 1.504)
Widowed	0.730***	(0.677, 0.788)	0.734***	(0.680, 0.792)
Other	0.888	(0.770, 1.020)	0.893	(0.777, 1.028)
Year of education *(Ref. no full-time education/ less than 15 years)*				
16-19 years	1.064**	(1.016, 1.114)	1.066**	(1.019, 1.117)

	Model 4		**Model 5**	
	OR	95% CI	OR	95% CI
20 years and more	0.689***	(0.653, 0.726)	0.692***	(0.657, 0.730)
Still studying	0.326***	(0.297, 0.357)	0.330***	(0.301, 0.362)
Community type *(Ref. rural area/ village)*				
Small/ middle town	1.119***	(1.080, 1.160)	1.120***	(1.080, 1.161)
Large town	1.220***	(1.174, 1.267)	1.218***	(1.173, 1.266)
Difficulty in paying bills *(Ref. most of the time)*				
From time to time	0.713***	(0.679, 0.749)	0.712***	(0.678, 0.747)
Almost never/ never	0.488***	(0.465, 0.512)	0.487***	(0.464, 0.511)
Country-year-level				
TCS score (longitudinal)	0.999	(0.994, 1.005)	0.999	(0.993, 1.005)
Country-level				
TCS score (cross-sectional)	0.990*	(0.983, 0.998)	0.988**	(0.980, 0.996)
Cross-level interaction				
*(Ref. TCS (cross-sectional) * manual class)*				
TCS (cross-sectional) * middle class			0.996	(0.992, 1.000)
TCS (cross-sectional) * upper class			0.985***	(0.978, 0.992)
TCS (cross-sectional) * inactive			1.009***	(1.005, 1.013)
	Variance	95% CI	Variance	95% CI
Random effects				
Country-level intercept	0.066***	(0.035, 0.120)	0.066***	(0.034, 0.119)
Country-level slope on year	-0.004**	(-0.010, -0.001)	0.001**	(0.000, 0.002)
Country-year-level intercept	0.001*	(0.000, 0.002)	0.004*	(0.001, 0.009)
DIC	110,096		109,996	

* p<0.05, **p<0.01, ***p<0.001

DISCUSSION

Key Results

In this study, we examined change in smoking prevalence between 2009 and 2017 in 28 EU member states; the relationship between the strength of national tobacco control policies and the odds of being a current smoker; and the relative effect of tobacco control policies on people of different occupational groups.

We found that there was a general trend of decreasing smoking prevalence over the last decade in the EU. However, there was significant variation at the country- and country-year-levels in the models indicating that countries differed significantly in their trajectories of smoking prevalence. We also found that cross-nationally, strong tobacco control policies were significantly associated with lower odds of being a current smoker. In contrast, we found no effect of longitudinal changes in TCS score on probability of current smoking. We also found that average TCS scores had a much greater effect on the odds of being a current smoker in upper class occupations. Higher TCS scores had significantly less impact on people who are economically inactive.

Interpretation of Findings

Our findings are similar to those of two recent ecological studies by Feliu, et al. [9] (2018) and Lidón-Moyano, et al. [10] (2017). Feliu, et al. [9] found that there was a negative association between TCS score and the prevalence of smokers in 2014 and a positive association between TCS scores and the relative change in smokers' prevalence from 2006 to 2014. Our current study adds to these findings by estimating subject-specific effects. Model 4 shows that a one-point increase in the average TCS score for a country was associated with a 1% decrease in the odds of an individual being a current smoker (with all other variables held constant and conditional on the random effects). The reason that the earlier paper by Schaap, et al. [11] did not conclude that the effect of TCS differed by education level is mostly likely due to the following methodological differences. Firstly, they examined 'quit ratios' as primary outcome rather than current smoking and secondly they evaluated the effect of educational difference through the use of the Relative Index of Inequality.

There are a number of possible interpretations of the absence of a longitudinal effect. Firstly, most countries' TCS scores changed very little over time limiting the scope for detecting effects. Second, the probability of an increasing TCS within a country may be highly correlated with its' longitudinal trend in smoking prevalence. That is, there may be endogeneity, in which countries with rapidly declining smoking prevalence may also have a critical mass of anti-smoking sentiment so that that politicians and the public are supportive of increasing tobacco control measures. [30] Therefore, some of the effects of small changes in TCS will be included in the country and country-year specific random effects. This is because the country level slope over time on odds of smoking is modelled, therefore the effects of longitudinal (within-country) change in TCS that are evaluated are only those uncorrelated with change in smoking prevalence over time.

Other research has also suggested that a comprehensive range of tobacco control policies at the highest levels of implementation are required in order for there to be a longitudinal effect[31] and including one or two measures at lower levels may not be sufficient to influence smoking prevalence.

The differential effect of tobacco control policies on different socio-economic groups has also been observed in other studies. Bosdriesz, et al. [17], for example, found that the strength of country-level tobacco control policies had much less of an effect on smoking cessation and tobacco consumption amongst the economically inactive compared to those in manual occupations. We have extended these findings and can confirm the same association holds for probability of current smoking. Reviews on this topic suggest that tobacco control policies need to be tailored to addressing inequalities by the specific targeting of cessation support and mass media campaigns towards disadvantaged groups.[32 33] There is some evidence that interventions around price are most effective at reducing inequalities.[16] However, the TCS is already weighted towards price and nevertheless the total TCS score has less impact in the lower occupational categories.

The tobacco epidemic in Western countries has had very distinct phases in terms of occupational social class.[34] The early adoption of mass produced factory cigarettes was by upper and middle class males with subsequent diffusion to other groups. More advantaged groups were also the first to start to quit smoking in large numbers. This has been explained in terms of Bourdieu's ideas of habitus and distinction.[35] Smoking is seen as an example of the use of the body, appearance and habits to define and

distance social groups. Initially smoking was a mark of Epicureanism and sophistication associated with upper class tastes and was abandoned precisely because widespread adoption meant it no longer evoked distinction. It has now become a marker of lower class lack of self-control. It has been suggested that class stigma has become smoking stigma.[36] This, however, only operates across class boundaries. Sorenson[37] found greater acceptability of smoking among blue collar workers and lower social support for quitting. In other words, smoking became a social norm among the lower class. From this perspective, tobacco control policies represent and recreate middle class attitudes to smoking, as an object of disgust, putting greater pressure on residual middle class smokers but with little influence on people who identify as manual class.

Strengths and Limitations

This study is the first to use a repeated cross-sectional design to examine smoking prevalence in 28 EU member states across 2009 to 2017. We applied a three-level random slope logistic regression with MCMC estimation to analyse repeated cross-national data. Our study extends previous research in a number of ways. First, the analysis used multilevel mixed effects models with random effects at the country and country-year levels. The inclusion of year as a fixed effect at the country-year-level allows the overall trajectory of smoking over time to be modelled. Random intercept at country-year-level examines how the specific country-year-trajectory deviates from the country trajectory over time whereas the random slope for year at country-level allows country-level trajectories to deviate from the overall trajectory. Further, we decomposed the effect of TCS into the cross-sectional (between-countries) and longitudinal (within-country) components. The longitudinal (within-country) estimator has the property that it controls for unobserved between country heterogeneity. Third, we examined the interaction between the cross-sectional component of the TCS and occupational group in a model adjusted for individual-level sociodemographic variables.

Socioeconomic position is a complex multifaceted concept.[13] We used occupation as a crude proxy for social class. We recognise that the measure that we have employed here only captures some broad elements of socioeconomic position therefore there is some risk of information bias. The economically inactive accounted for approximately half our sample. They likely represent a broad and heterogeneous group and this initial analysis should therefore be treated with caution. This clearly requires further

study. It is also possible that there are interaction effects between gender and socioeconomic group. Investigation of more complex interactions however is beyond the scope of this study.

CONCLUSIONS

Over the last decade, smoking prevalence has decreased but smoking remains a leading cause of premature morbidity and mortality in the EU. Differences in tobacco control policies between countries were associated with probability of smoking but the difference in TCS within countries over time was not. This is probably because it is not possible to disentangle the effect of within-country factors such as public attitudes to smoking and previous rates of decline in smoking prevalence from country-level TCS scores. We found that the effect of between-country differences in TCS score had a much stronger relationship with probability of smoking in people who were in upper occupational groups than in people who were in manual groups or were economically inactive.

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Competing Interest: None declared.

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